University of California, Berkeley
Physics H7C Fall 2002 (*Strovink*)

PROBLEM SET 6

1.
Babinet's principle states, in the scalar-field approximation, that the optical disturbance $U_{\rm ap}$ downstream of an aperture in an opaque screen, plus the optical disturbance $U_{\rm comp}$ downstream of a *complementary* aperture, is equal to the optical disturbance $U_{\rm no}$ that would be present if there were no screen at all:

$$U_{\rm ap} + U_{\rm comp} = U_{\rm no} \ .$$

Nevertheless, the on-axis irradiance downstream of a one-Fresnel-zone circular hole is four times the on-axis irradiance downstream of a one-Fresnel-zone circular disk. How can you reconcile this fact with Babinet's principle?

2.
A plane wave incident along $\hat{z}$ yields an irradiance I_0 as seen by an observer stationed somewhere on the positive z axis. Now an opaque knife edge, occupying the semi-infinite plane $(-\infty < x < \infty, -\infty < y < 0, z = 0)$, is inserted to intercept part of this wave. What irradiance does the observer now detect?

3.
A plane wave of wavelength λ incident along $\hat{z}$ yields an irradiance I_0 as seen by an observer stationed at $(x = 0, y = 0, z = h)$, where $h > 0$. Now an opaque annular flat washer, centered on the z axis and occupying the plane $z = 0$, is inserted to intercept part of this wave. The inner and outer radii of the washer are R and $2R$, respectively, where $R \ll h$. The observer detects an irradiance of $9I_0$.
(a.) Furnish the smallest value of R that is consistent with these observations.
(b.)
Finally, half of the washer is cut away and discarded, leaving a "C" (for Cal). In terms of I_0, what irradiance is finally observed?

4.
Bernstein 4-16.

5.
Bernstein 4-18.

6.
Bernstein 4-24.

7.
Nuclear winter (inverse Greenhouse effect).
According to some experts (though this is controversial), after nuclear war a thin layer of dust would remain in the upper atmosphere of the earth. To a first approximation, the dust would absorb all light from the sun, which is near visible in wavelength. The dust then would reradiate that energy in the infrared, to which it is transparent: half in toward the earth, half out to space. The dust is nearly transparent to the earth's outward radiation, which is also in the infrared.

If the peacetime surface temperature of the earth is 300 K, what would that temperature become after nuclear war? To relate to it physiologically, express your result in °F.

8. Bernstein 4-27.